Comparison of Platelet Rich Plasma and Bone Marrow Aspirate Concentrate for Osteoprogenitor Cell Retention and Osteoinductive Potential for Osteochondral Allografts

James L. Cook, Charles A. Baumann, Aaron M. Stoker, Farrah A. Monibi, Nicole L. Walden, Brett D. Crist, Mauricio Kfuri, Matthew J. Smith, and James P. Stannard

Thompson Laboratory for Regenerative Orthopaedics & Mizzou BioJointSM Center, University of Missouri, Columbia

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Introduction

Osteochondral allograft (OCA) transplantation is effective for treatment of large articular defects in the knee, hip, ankle, and shoulder of athletes. While success after OCA transplantation is good, one mechanism of failure involves incomplete integration of OCA bone into recipient bone. Because the OCA bone is devoid of viable cells and blood supply at implantation, and is allogeneic, integration is dependent upon cellular repopulation and neovascularization via creeping substitution. Enhancing this process using bone marrow aspirate concentrate (BMC) or platelet rich plasma (PRP) could minimize graft failures and improve patient outcomes.

Hypothesis

BMC would be associated with superior viable osteoprogenitor cell repopulation of OCAs and osteoinductive protein production compared to PRP and saline using an ex vivo model.

Materials & Methods

With ACUC approval, BMC and leukoreduced PRP were processed from BMA (proximal humerus) and whole blood (jugular vein), respectively, of adult dogs using a commercially available system. Femoral condyles were harvested from adult dogs (n=3) immediately after euthanasia for unrelated reasons and preserved using tissue bank protocol. On day 21 of preservation, cylindrical OCAs (8 mm diam x 8 mm depth) were created (n=36; 12/dog), and randomly assigned to treatments: (1) NEG – bone portion of OCA lavaged with 10 ml saline, (2) BMC – bone portion of OCA lavaged, dried, and then saturated with 0.5 ml BMC to mimic clinical use (Fig. 1), (3) PRP – bone portion of OCA lavaged, dried, and then saturated with 0.5 ml PRP. OCAs were cultured for 7 or 14 days (n=6/group/day), media were changed and collected on days 3, 7, and 14 for biomarker analysis. On days 7 and 14, OCAs were evaluated for viable cell colonization and infiltration using Calcein AM staining. To determine if cells were osteoprogenitors, colony forming unit (CFU) analysis was performed using crystal violet staining to determine CFUs/ml for each BMC and PRP sample. OCA culture media were assessed for alkaline phosphatase (ALP), dickkopf-related protein (DKK), osteoprotegerin (OPG), osteopontin (OPN), adrenocorticotropic hormone (ACTH), bone morphogenetic protein-2 (BMP-2), and bone morphogenetic protein-7 (BMP-7) using commercially available assays. Data were compared for statistically significance (p≤0.05) differences.

Results

For all BMC OCAs, viable cells were present on the surface and deep areas of the bone at days 7 and 14. Viable cells were not observed in any part of the bone of PRP or NEG OCAs at either time point (Fig. 2). BMC samples had a significantly higher (p=0.029) CFU/ml compared to PRP (Fig. 3). Concentrations of OPG were significantly higher in BMC and PRP compared to NEG at days 3 (p<0.001) and 7 (p≤0.004). The concentration of DKK was significantly (p=0.038) higher in BMC compared to NEG at day 3. Concentrations of BMP-2 were significantly higher in BMC at days 3 (p=0.001) and 7 (p=0.017) and PRP at day 3 (p=0.009) compared to NEG. The concentration of ALP was significantly lower in PRP compared to NEG at day 3 (p=0.03). Concentrations of BMP-7 and OPN were below detectable limits of the assay for all groups and time points (Fig. 4).

Conclusions

BMC showed superior viable osteoprogenitor cell repopulation of OCAs and osteoinductive protein production compared to PRP and the current standard-of-care (saline). BMC has potential to enhance integration of osteochondral allograft bone and improve graft survivorship and patient outcomes.